EnergyIQ

Action-oriented Benchmarking for Non-Residential Buildings

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Roadmap

- Why benchmark?
- What to benchmark?
- Some history of efforts (LBNL and beyond)
- EnergyIQ
  - Approach
  - Walkthrough
  - Technology transfer efforts
  - Drilldown documentation
  - Challenges

Why benchmark energy?

- Establish baseline and track performance
- Inform and (later) validate design
- Identify best practices; set goals or standards
- Prioritize efforts
- Identify savings potential
- Educate; Inspire!

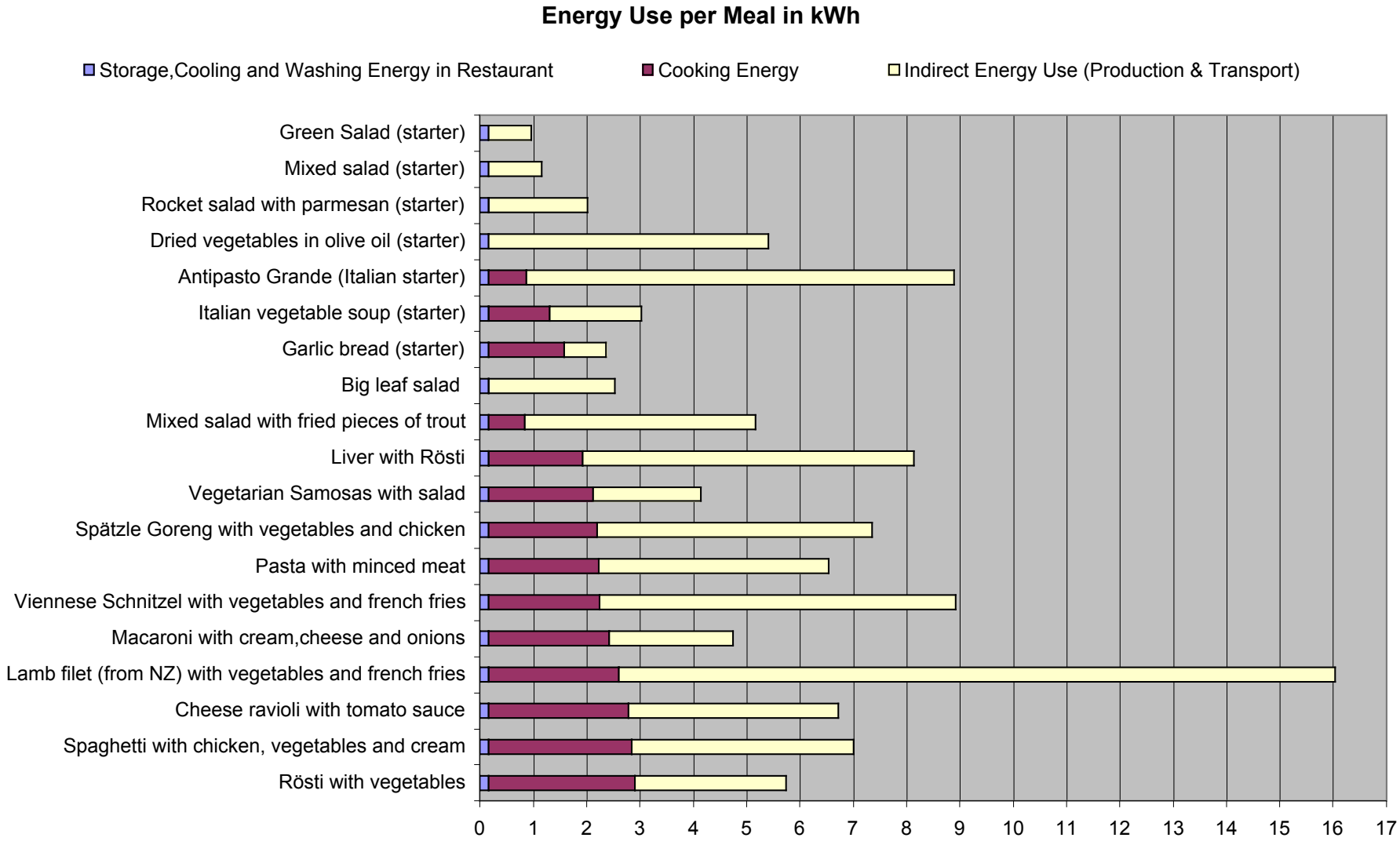
Energy benchmarking is one part of a broader energy management process

What to benchmark?

"To define an energy efficiency indicator is not only a technical challenge, but also a pre-structuring of the subsequent policy choice."

»Aebischer, 2003

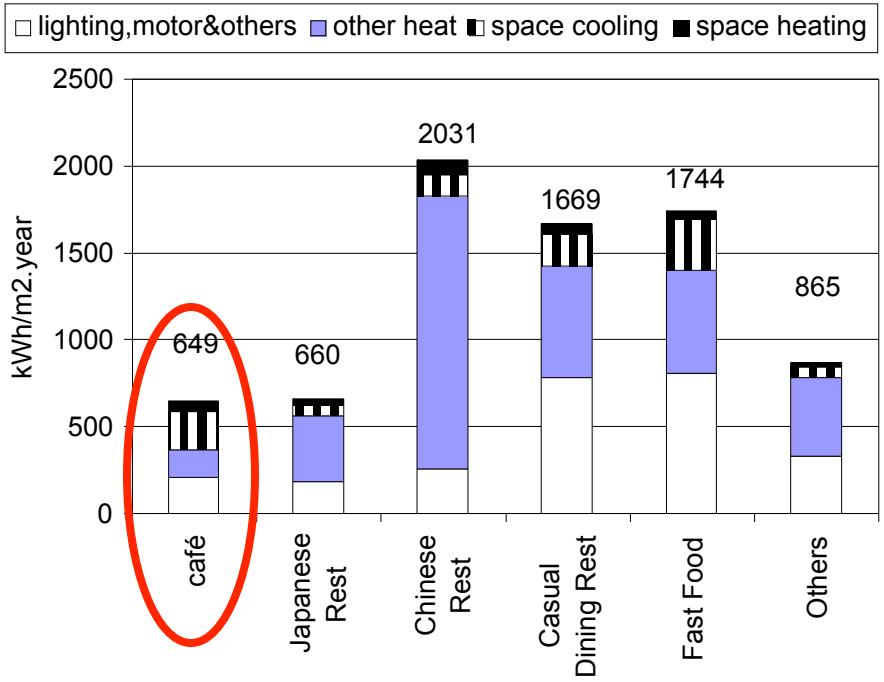
Benchmarking as only the Swiss can do it



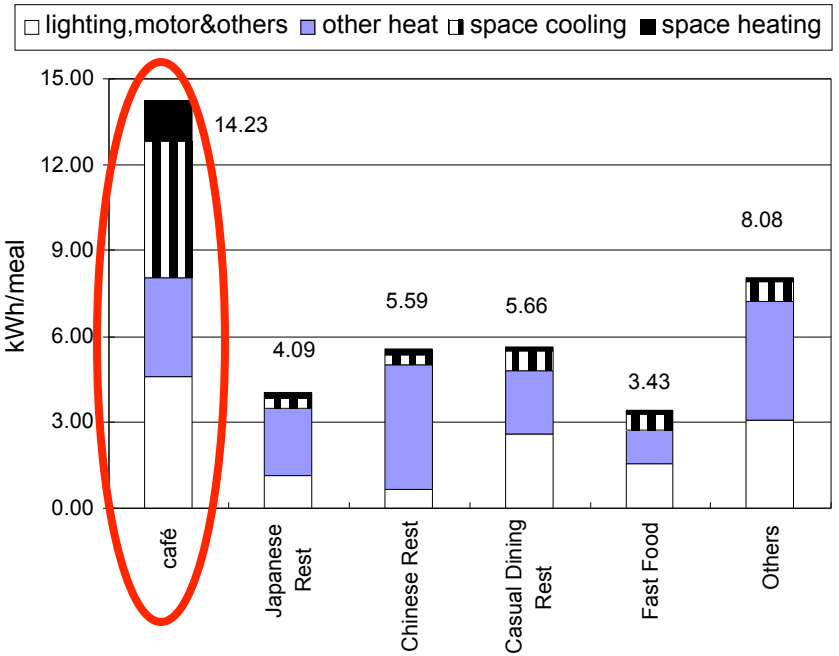
Data for Switzerland. Source: Balmer and Hintermann, 2000

Choice of indicator is key

Energy per unit floor area



Energy per meal

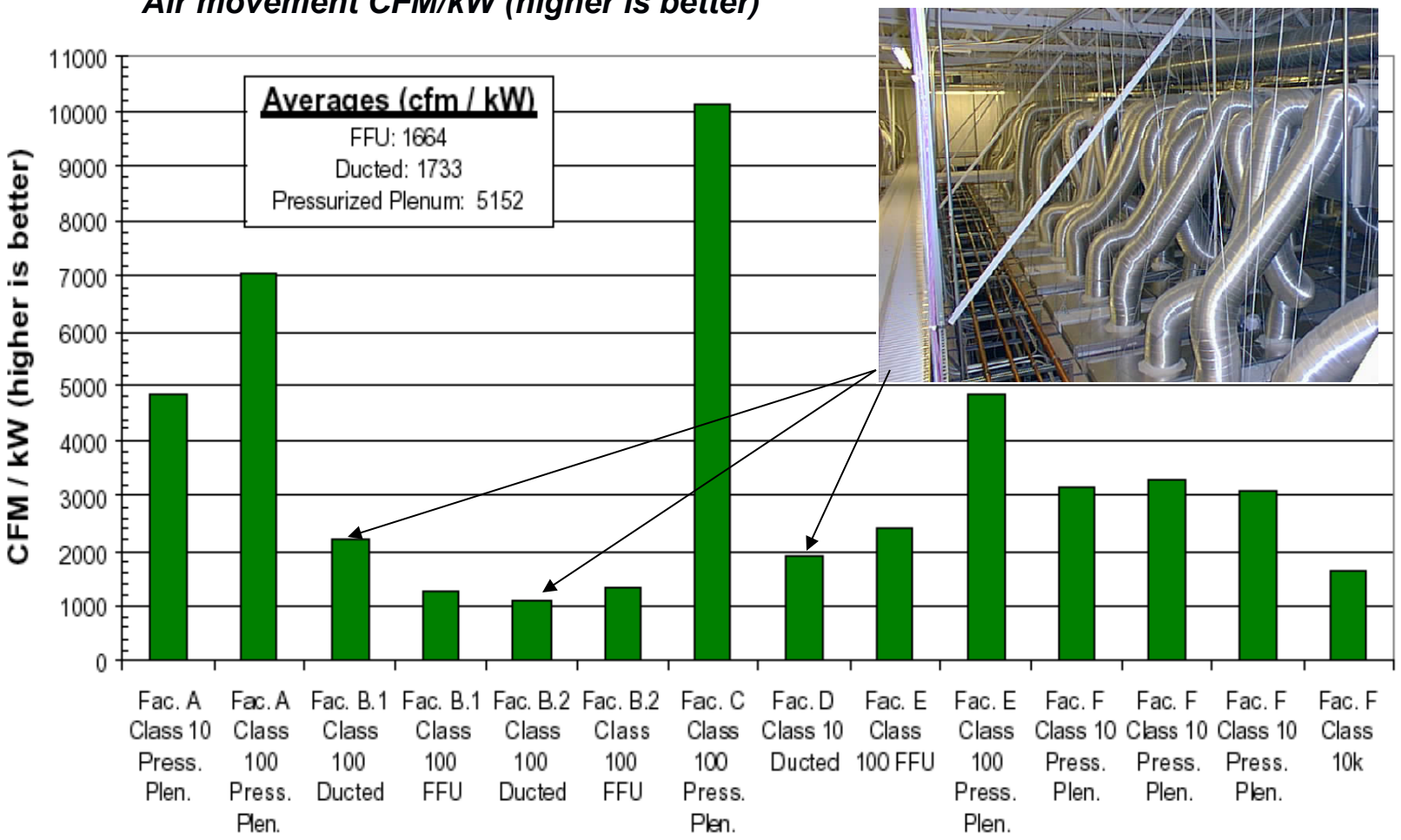


Café ranks "best" by one benchmark and "worst" by the other

Source: The Energy Data and Modeling Center, 2001

Subsystem benchmarking

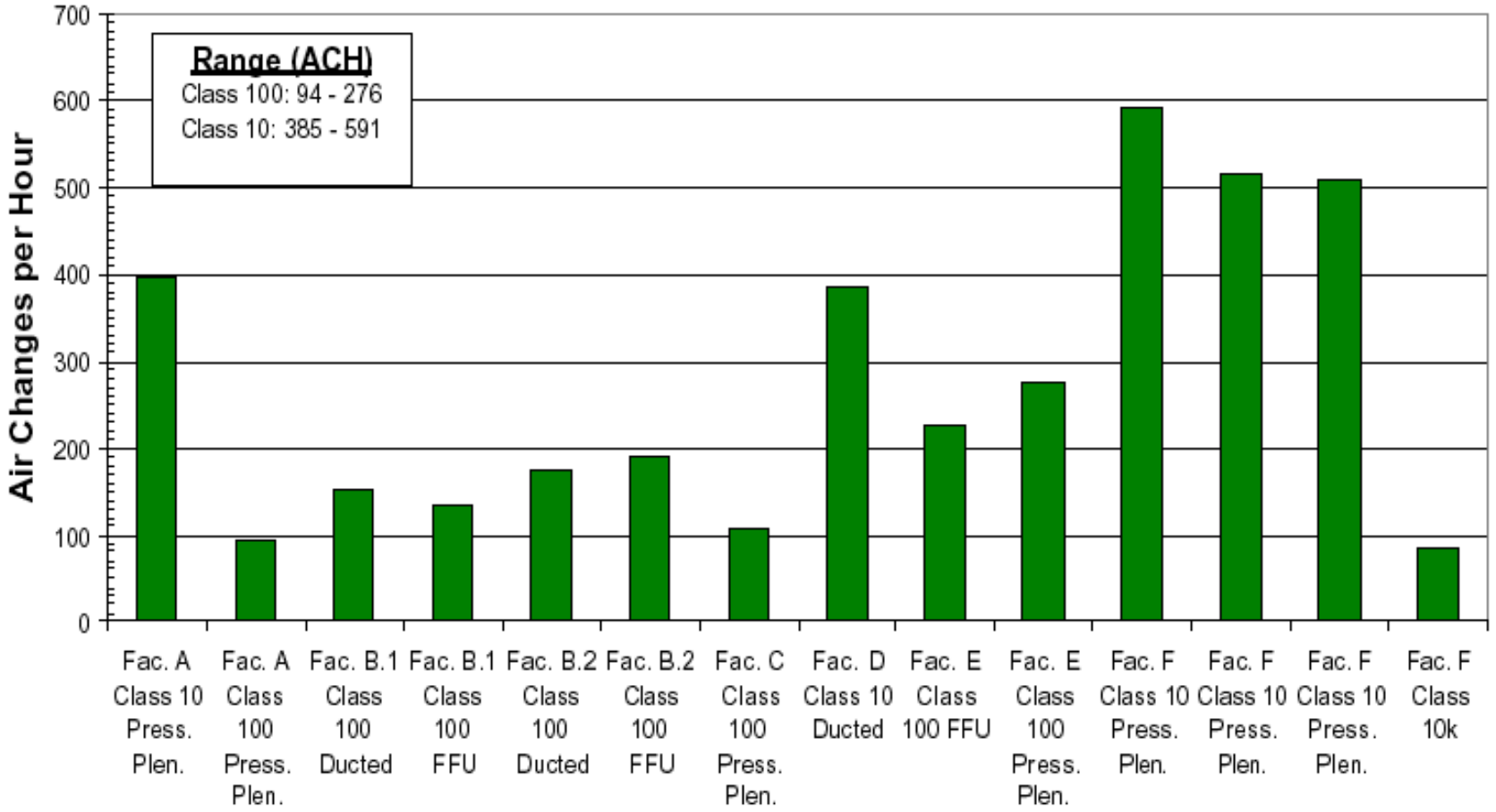
Air movement CFM/kW (higher is better)



Tschudi and Xu, ASHRAE Transactions, KC-03-9-4 (2003)

“Service-level” benchmarking

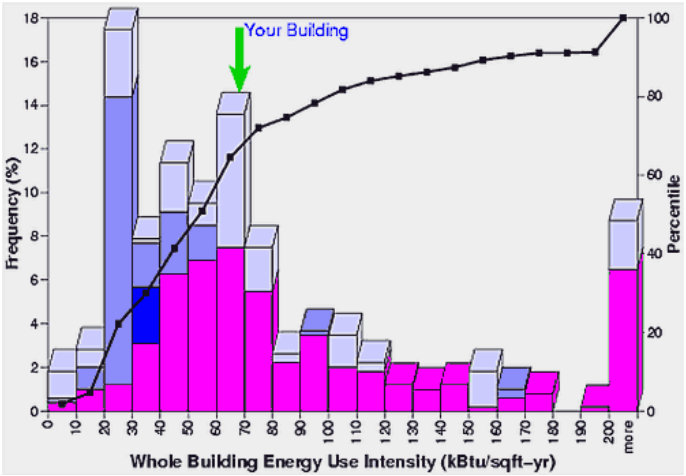
Air-changes per hour in Cleanrooms



Tschudi and Xu, ASHRAE Transactions, KC-03-9-4 (2003)

Buildings energy benchmarking

- LBNL
  - Commercial bldgs: Cal-ARCH – early 2000s
  - High-tech facilities
  - EnergyIQ started in 2006
- EPA
  - Portfolio Manager
- Others
  - HERS
  - LEED
  - …



EnergyIQ – User-centered Development

EnergyIQ team

- **Evan Mills** — Project lead — LBNL
- **Paul Mathew** — Analysis and Co-Leader — LBNL
- **Andrea Mercado** — Development Support, Testing, Customer Care — LBNL
- **Bob Ramirez** – iTron – Energy upgrade simulations
- **William Bordass Associates and the Usable Buildings Trust** — Advisors
- **Chris Ralph & Robert Garcia** — Programming and infrastructure — Bighead Technology (originally LBNL IT department … but we won't talk about that in mixed company)
- **Kath Straub** — Usability and information design — Usability.org
- **Karen Fojas Lee** — Visual design — Nomad Chique
- **uTest** – Acceptance testing

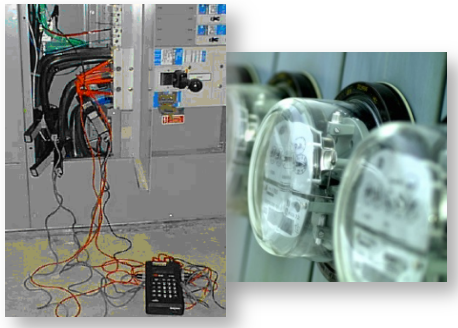
Action-oriented benchmarking extends whole-building benchmarking

Whole Building Energy Benchmarking

Screen facilities for overall performance and potential

Minimal data requirements (utility bills, minimal information on building features)

Action-Oriented Energy Benchmarking



Identifies and prioritizes specific opportunities or design options

More granularity: Uses system features and end-use data; may require additional data logging

Can inform RCx and Cx

Investment-Grade Energy Audit

Estimates savings and cost for specific opportunities

Requires detailed data collection, simulation, cost estimation, financial analysis

Necessary for retrofits with capital investments

What is it?

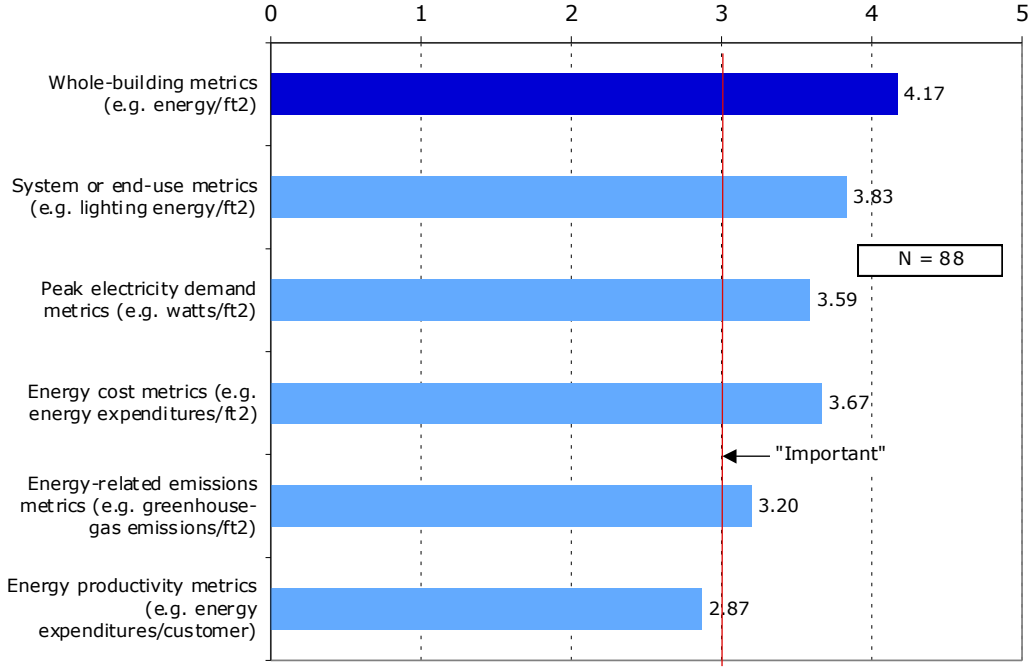
- A low-effort bridge between whole-building benchmarks and investment-grade audits
  - Quick energy+cost+carbon analysis, with multiple metrics
  - Web-based (somewhat novel in 2006 when we began)
  - Not a simulation or audit tool…
- Customizable comparisons to customizable peer groups
  - Currently CEUS 2006 – California (N=2,800 bldgs); US – CBECS 2003 (N=5,215 bldgs); EIQ users (~800 bldgs)
- "Action-oriented": Estimated savings of potential actions … light-touch; not an investment-grade audit
- Licenseable APIs enable integration with other tools
  - e.g. benchmark analysis can complement EIS reports
- Developed by LBL for CEC - supports AB 1103 & 758

Market Research

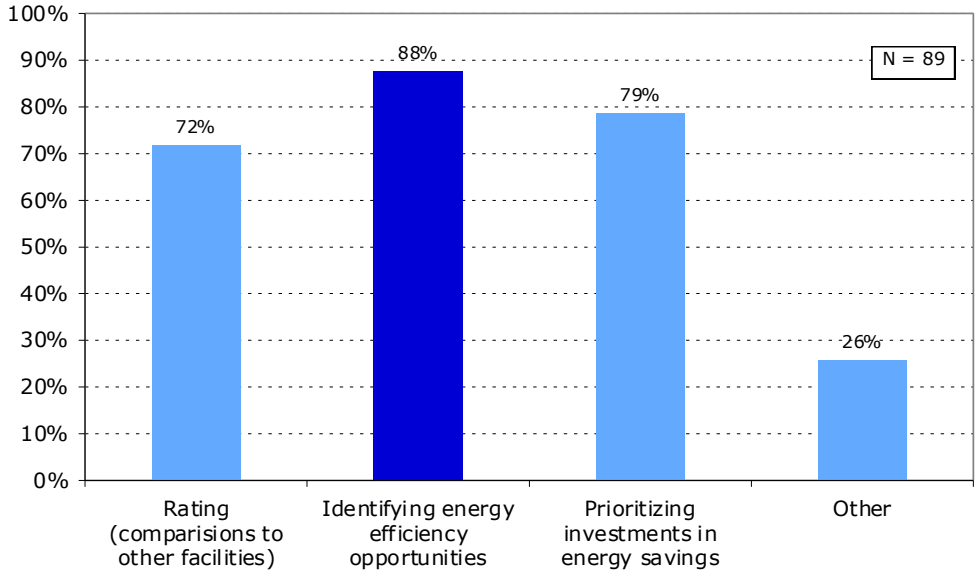
- Existing benchmarking practices
- Features desired in tool

- 101 respondents
  - Very good (20%) response rate; virtually all questions answered by each respondent
  - Respondents represent 554 million square feet of space directly influenced

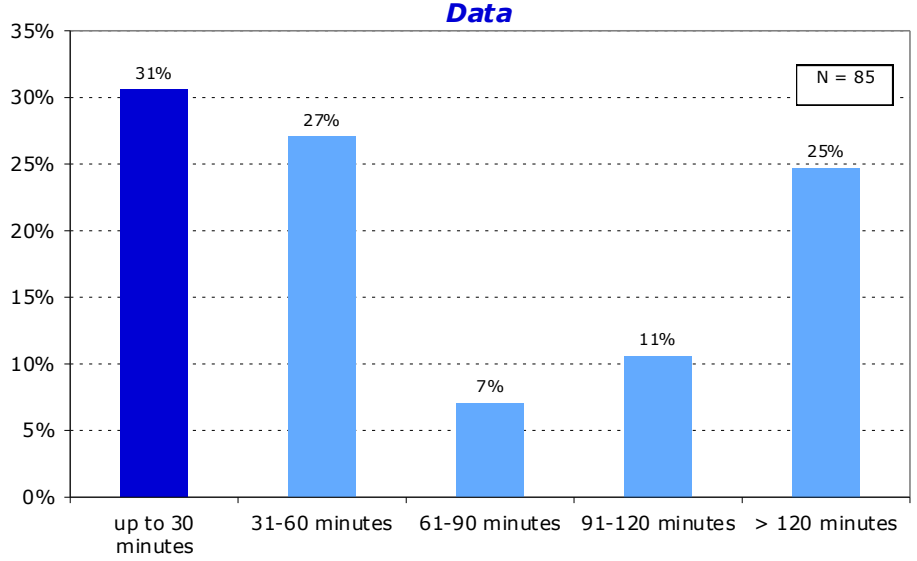
LBNL Benchmarking Survey
Importance of Metrics



LBNL Action-Oriented Benchmarking Survey
Reasons for Energy Benchmarking

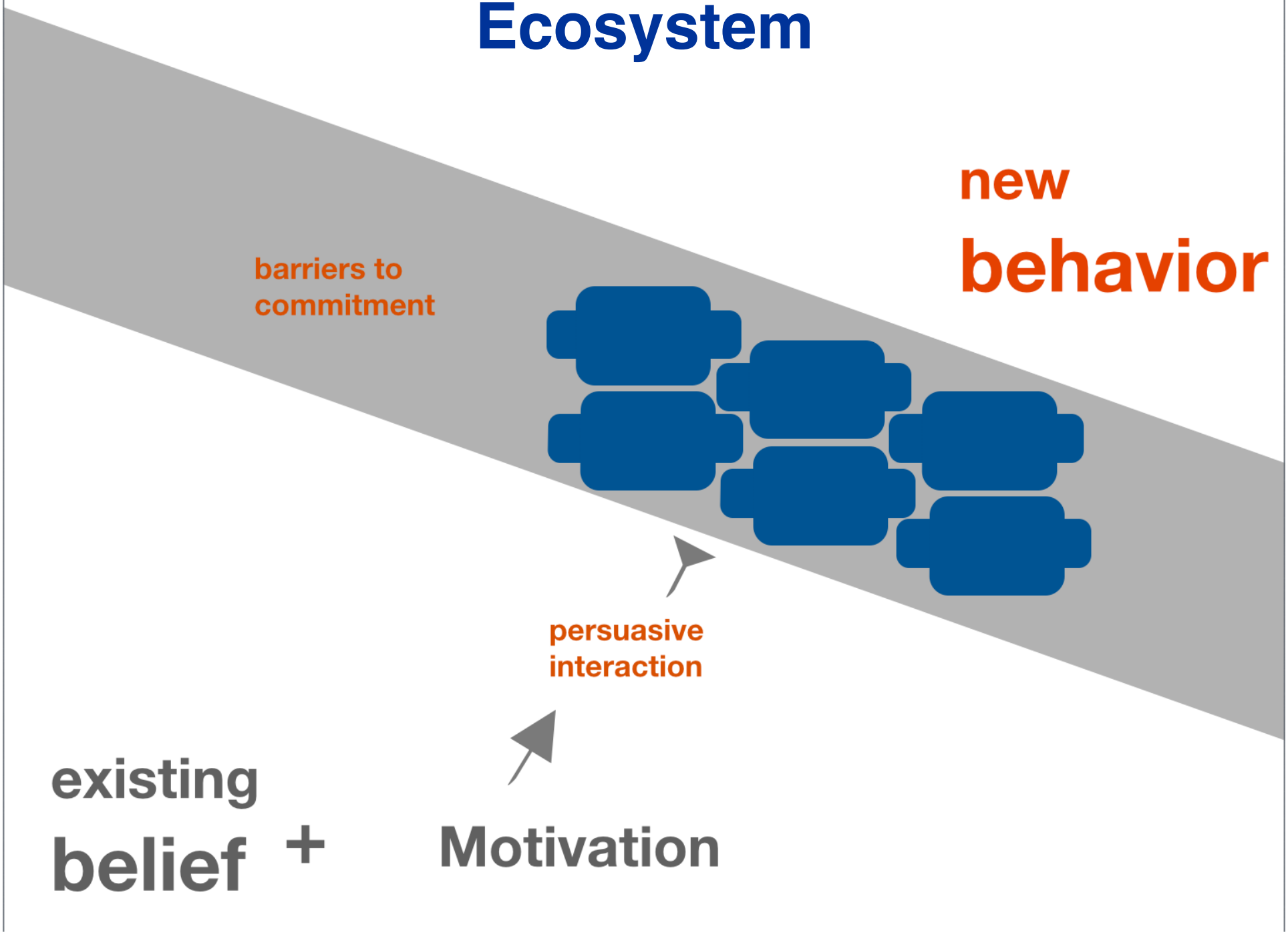


LBNL Action-Oriented Benchmarking Survey
Willingness to Spend Time Gathering/Entering Data



Ta Dah!

Ecosystem


new
behavior
barriers to
commitment
persuasive
interaction
existing
belief
+
Motivation

Ecosystem

Reduced energy use

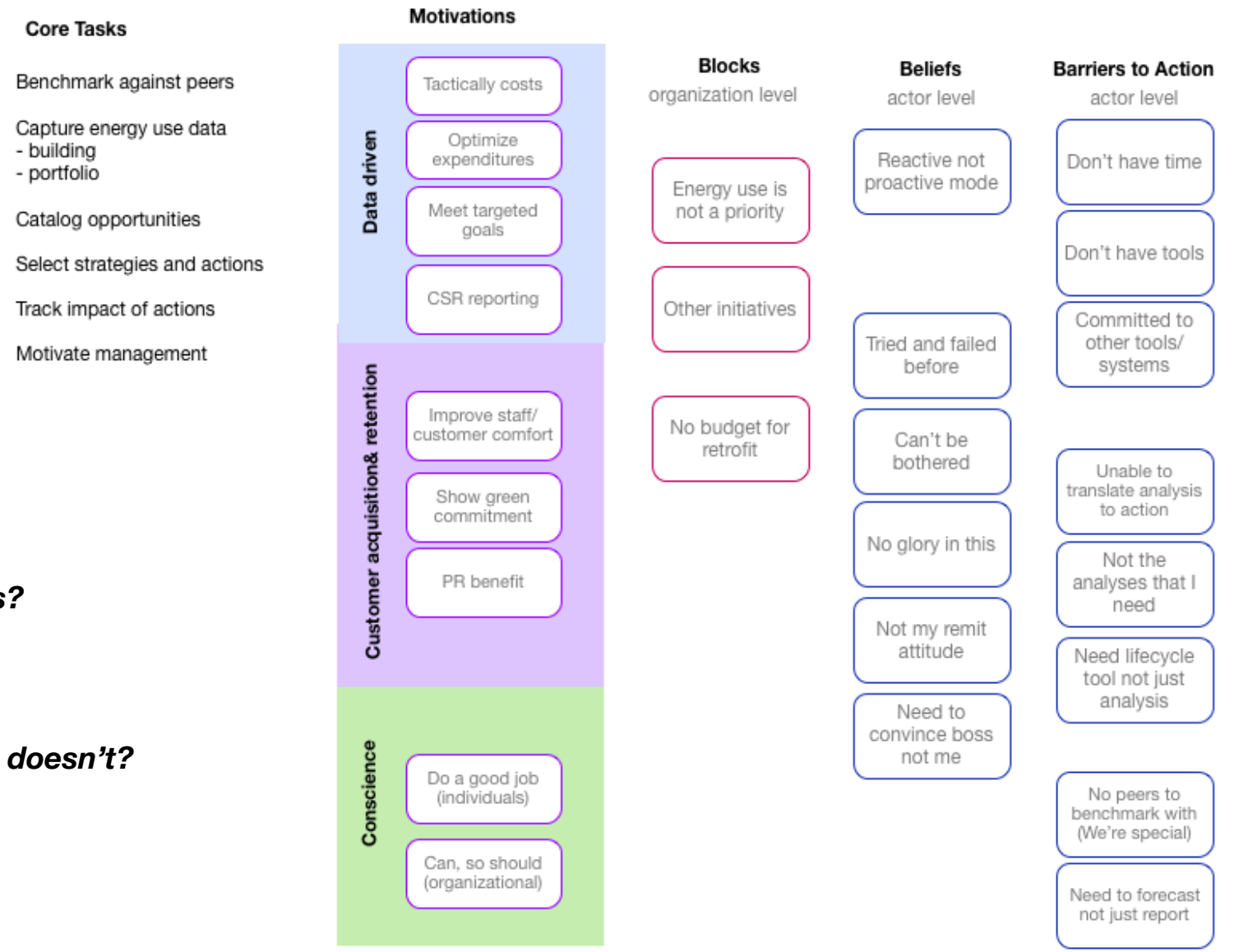
Motivation

Reduce costs CSR reporting Meet targeted goals Optimize expenditures **Data driven**	PR benefit Show green commitment Staff/customer comfort **Acquisition / Retention**	Can, so should (organizational) Do a good job (individuals) **Conscience**

User-centered design process: UNDERSTANDING USER NEEDS

User Interviews?

- ***Key tasks?***
- ***How done today?***
- ***Current pain points?***
- ***What tools? Why?***
- ***What works? What doesn't?***



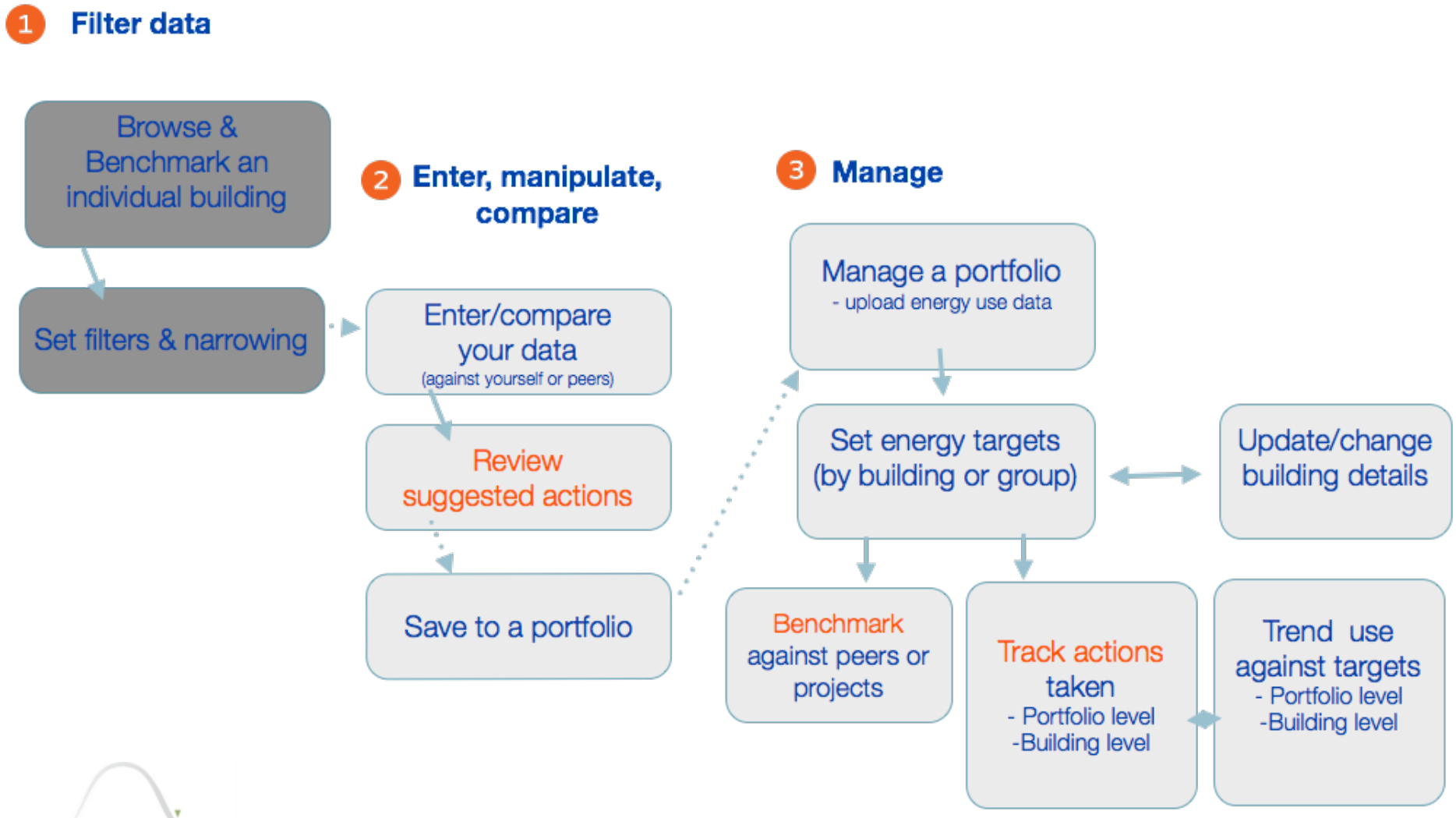
User-centered design process: User needs x best practice design

Step 1: Task Mapping and Prioritization – Who will do what?

		Browsers	Building Managers	Building Owners	Architects	Real Estate Purchasers
Benchmark	Benchmark/Browse the patterns of a peer group	x	x	x	x	
	Benchmark my building in relation to a peer group (via just-in-time data entry)	x	x	x	?	x
		x	x	x		
	Create an account		x	x		
Enter building data	Create buildings in a portfolio (Describe characteristics)		x	x	x	x
	Enter energy data (in aggregate, by hand)		x			x
	Upload energy data (via Energy Portfolio)					?
	Set energy use targets		x	?		
Review Actions	Review recommended actions	?	x	x	x	x
Track portfolio	Track actions over time		x	x		
	Benchmark my buildings w/ peer group				x	
	Save comparisons of interest		x			
	Configure my dashboard		x	x		
	Schedule/run reports - (includes Benchmarks)		x	x		
	Download data for further analysis		x	x	x	
	Print reports					
Learn	Learn about best practices	x	x	x	x	
About	Learn about the EIQ project					

User-centered Design: User needs x best practice design

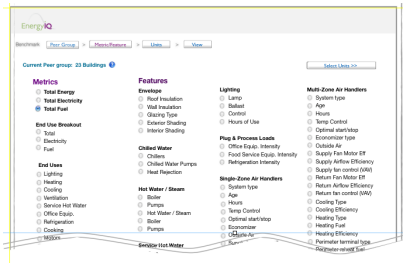
Step2 - Task Analysis & Information Architecture - How will it flow?



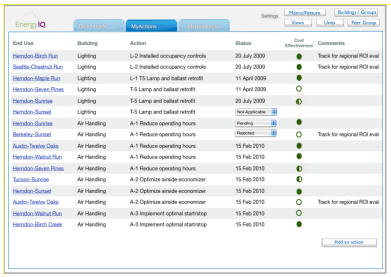
User-centered redesign: INTERACTION DESIGN: User needs x best practice design

Step 3- Wireframes – What does the interaction look like? What patterns emerge?

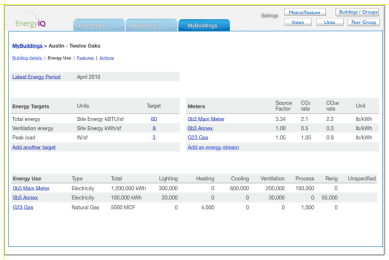
Benchmark

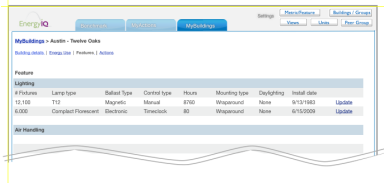


Act



Track

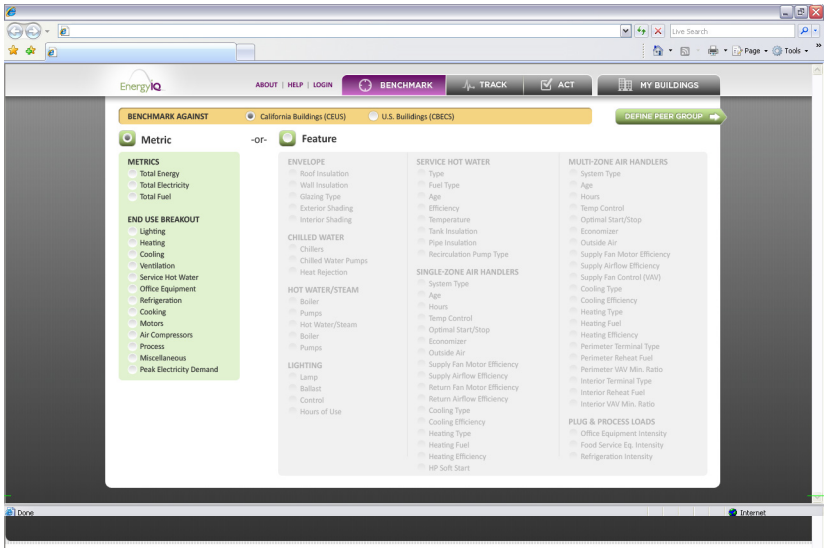


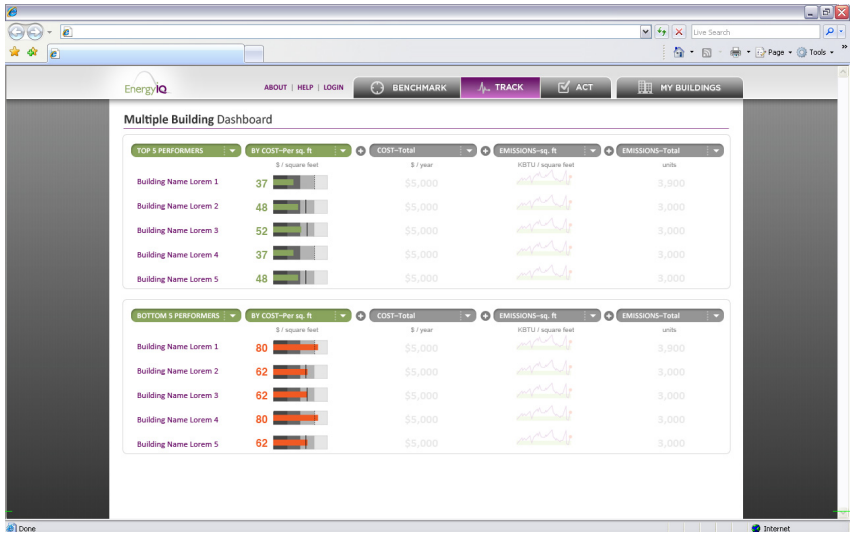


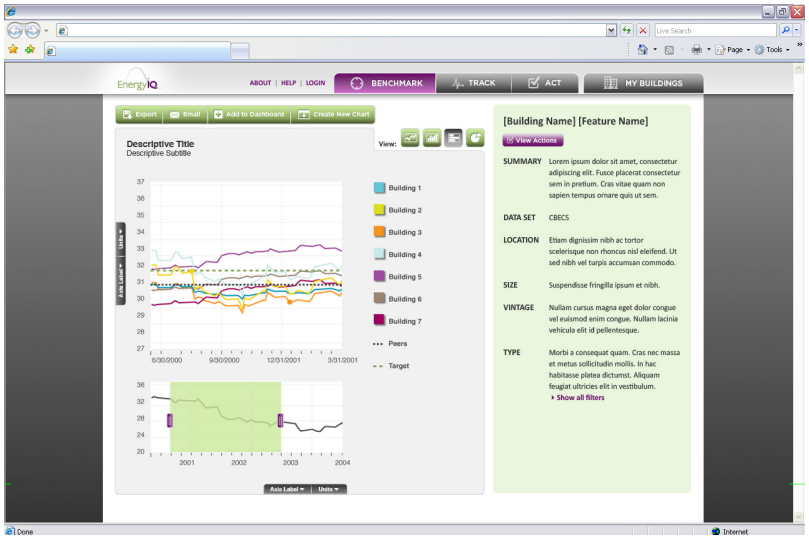
User-centered redesign: VISUAL DESIGN

Color and layout attributes

Draw user attention to key interactions and options







Formal Style Guide

Chart 1: Ranked Bar Chart with Container Frame

A. Descriptive Title = Helvetica, Bold, 14px, #464646
Offset = 16px from top and left of inside of frame
Descriptive Subtitle = Helvetica, Normal, 14px, #464646
Line Height = 14px

B. Utility Button Labels = Helvetica, Bold, 10px, #FFFFFF

C. Dataset Size = Helvetica, Normal, 11px, #B3B3B3
Inset 12px from left and top of frame

D. View = Helvetica, Bold, 11px, #464646

E. Axis Values/Labels = Helvetica, Normal, 11px, #464646
Offset = 10px from edge of frame

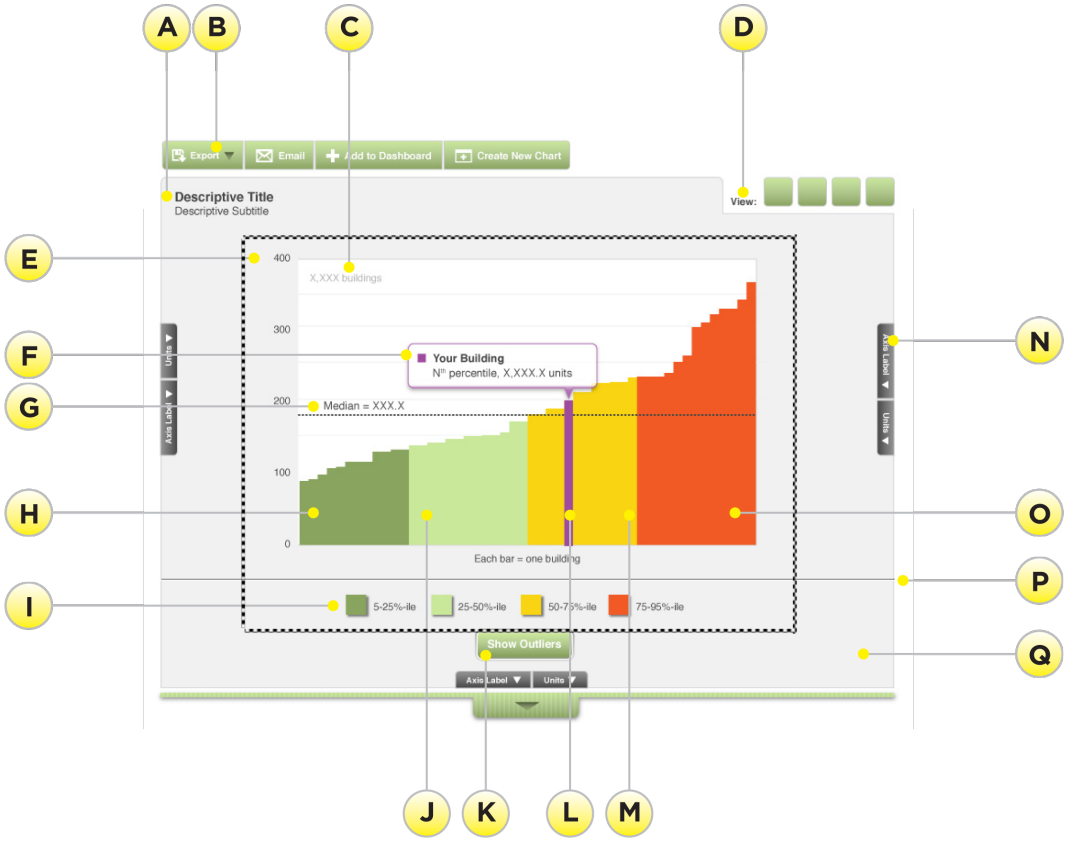
F. Callout Bubble:
Label = Helvetica, Bold, 12px, #464646
Bubble Outline = #9F4B9E, 1 px stroke, 6px corner radius, dropshadow
Label Units = Helvetica, Normal, 11 px, #464646

G. Median line = Helvetica, Normal, 12px, #464646; 2px dashed line with 2px gaps

H. 5-25%-ile = #89A45E

I. Legend Labels = Helvetica, Normal, 11 px, #464646;
Each legend swatch = 22 x 22 px with drop shadow

J. 25-50%-ile = #CAE89A



K. Button Label = Helvetica, Bold, 12px, #FFFFFF,
Use graphic for button

L. Your Building Bar = #9F4B9E

M. 50-75%-ile = #F8D413

N. Axis Label/Units Dropdown Menu = Helvetica, Bold, 9px, #FFFFFF

O. 75-95-ile = #F15A24

P. Legend Separator = 1px stroke, #FFFFFF
Dropshadow = 50% Black, X-offset, = 1px, Y-offset = -1px, Blur = 0px

Q. Background Fill = #EFEFEF
Outline = 1px stroke, #D7D7D7

Color Palette Used for this Chart:

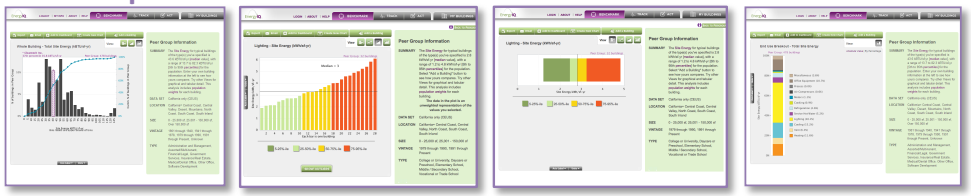
- #464646
- #9F4B9E
- #89A45E
- #CAE89A
- #F8D413
- #F15A24
- #D7D7D7
- #EFEFEF

Walkthrough

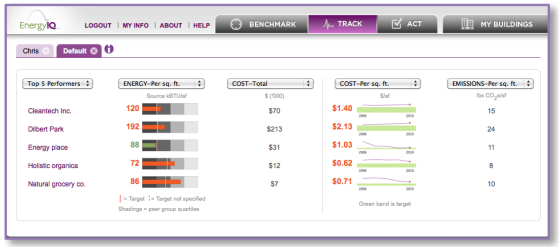
Action-Oriented Benchmarking with EnergyIQ

- ✓ **Rapidly benchmarks utility bills against user-defined peer groups => low-cost opportunity assessment**
- ✓ **Non-residential buildings: Peers drawn from CEC's CEUS for California and DOE's CBECS for rest of US**
- ✓ **Many choices of metrics and data visualizations**
- ✓ **Can import data from EPA's Portfolio Manager**

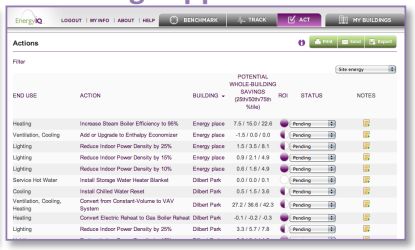
✓ Multiple data visualizations



✓ Dashboard



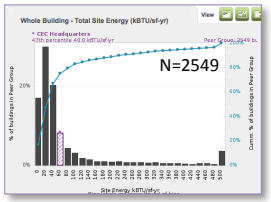
✓ Savings opportunities



Example: CEC Headquarters

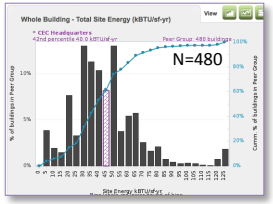
A building that is average when looked at coarsely, but among the best-in-class when benchmarked using progressively appropriate peer groups

Compared to …all California buildings

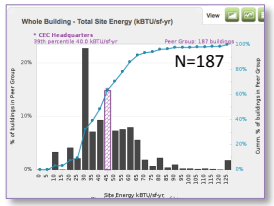


site energy (kBTU/sf-yr)

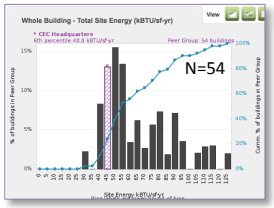
…+ only offices



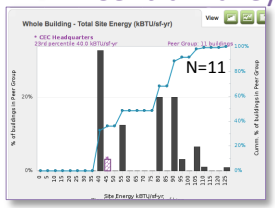
… + 1979-1990 vintage



… + 25-150k sf size range

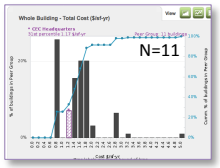


… + Central Valley

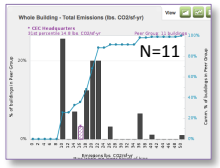


Other metrics ➔

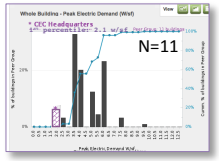
Energy cost



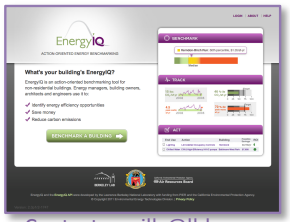
Carbon



Peak electricity



http://energyiq.lbl.gov



Contact: emills@lbl.gov

Market Uptake:

- ✓ 900 registered users
- ✓ 650 buildings benchmarked, representing 88 million sq. ft. floor area
- ✓ 14,000 unique visitors to website as of mid-2013

LOGIN | ABOUT | HELP

EnergyIQ

ACTION-ORIENTED ENERGY BENCHMARKING

What's your building's EnergyIQ?

EnergyIQ is an action-oriented benchmarking tool for non-residential buildings. Energy managers, building owners, architects and engineers use it to:

- ✔ Identify energy efficiency opportunities
- ✔ Save money
- ✔ Reduce carbon emissions

BENCHMARK A BUILDING

BERKELEY LAB

California Environmental Protection Agency
Air Resources Board

EnergyIQ and the EnergyIQ API were developed by the Lawrence Berkeley National Laboratory with funding from PIER and the California Environmental Protection Agency.
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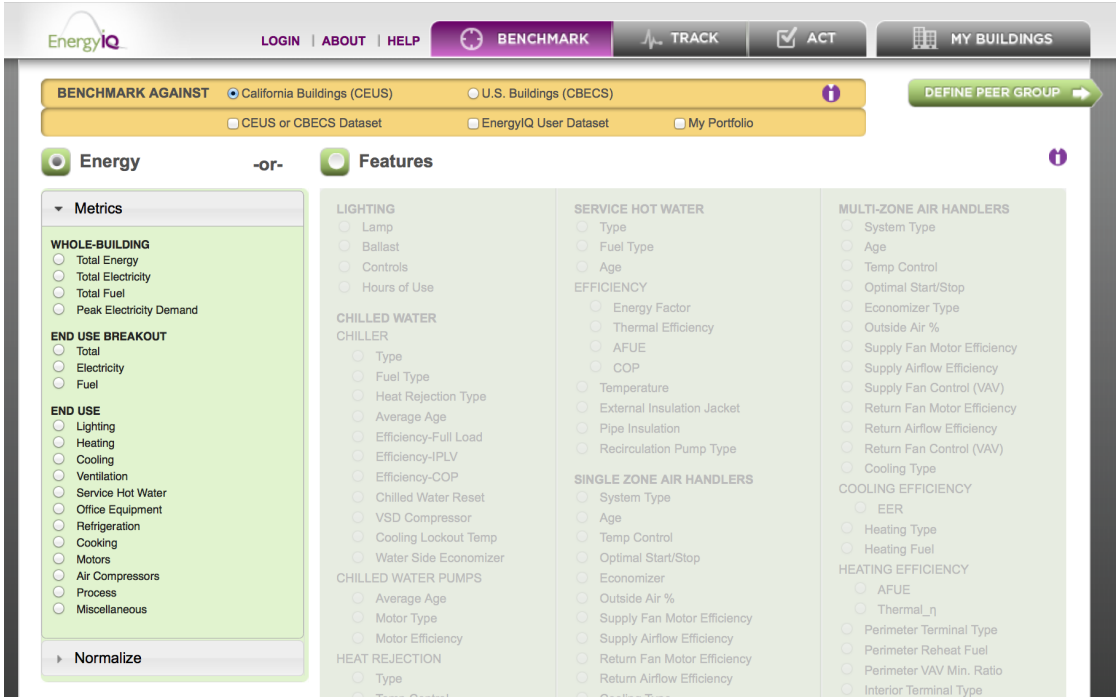
Version: 2.0p1r2-1747

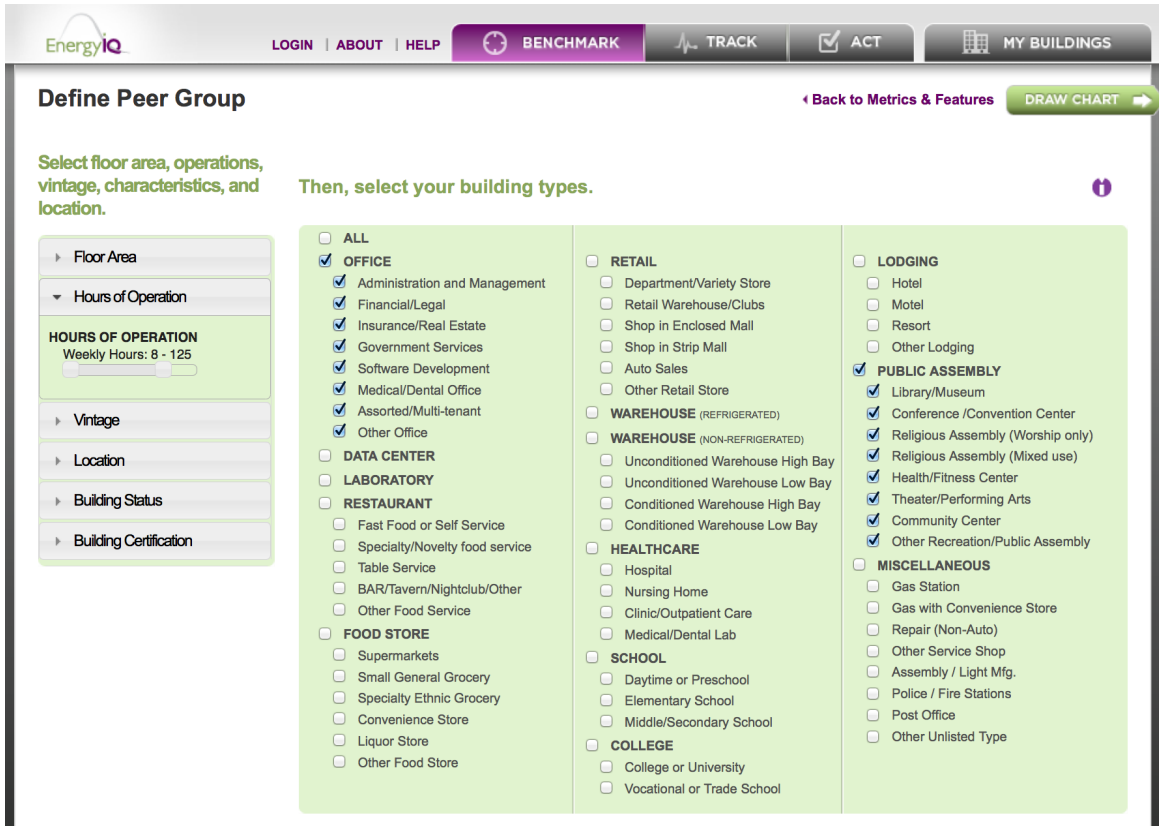
Select Metrics or Characteristics

- Choose population to benchmark against (California; Other US)
- Benchmark energy or characteristics
- Choose metric, and normalization units (e.g. floor area, employees, hotel beds)
  - Whole building
  - Fuel
  - End Uses



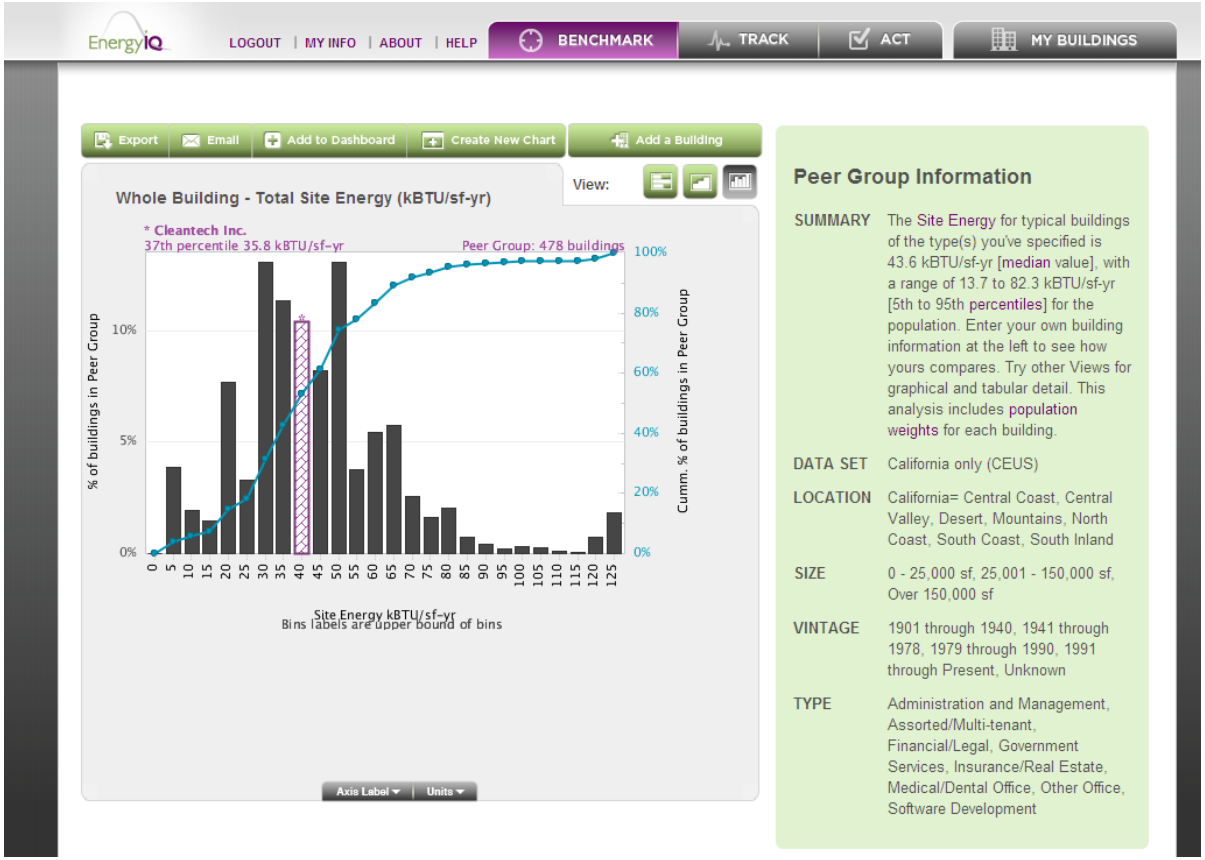
Define Peer Group

- Filter on
  - floor area
  - hours of operation
  - vintage
  - location
  - certifications
- Choose any combination of 62 building types

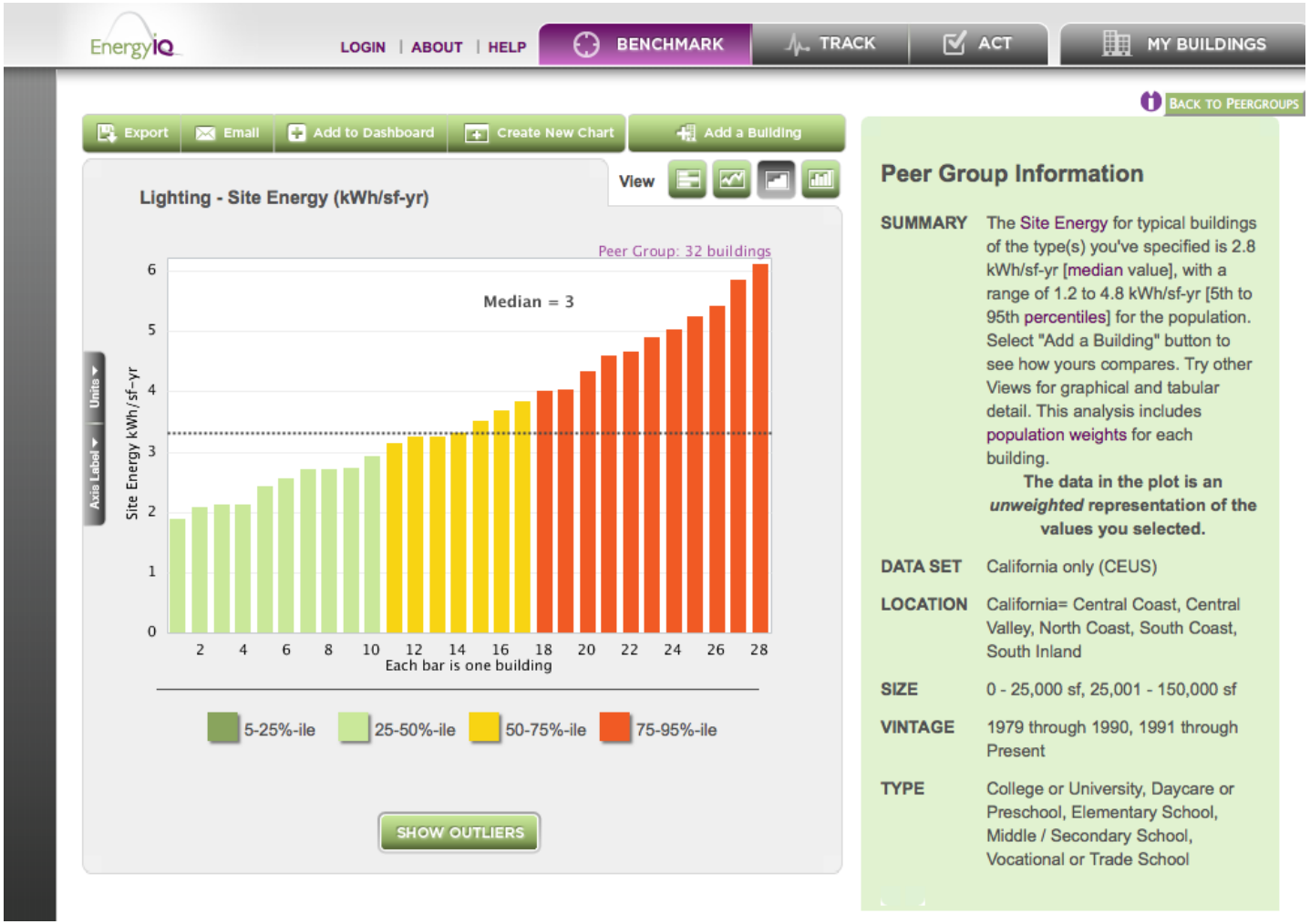


Benchmark: Frequency Distribution

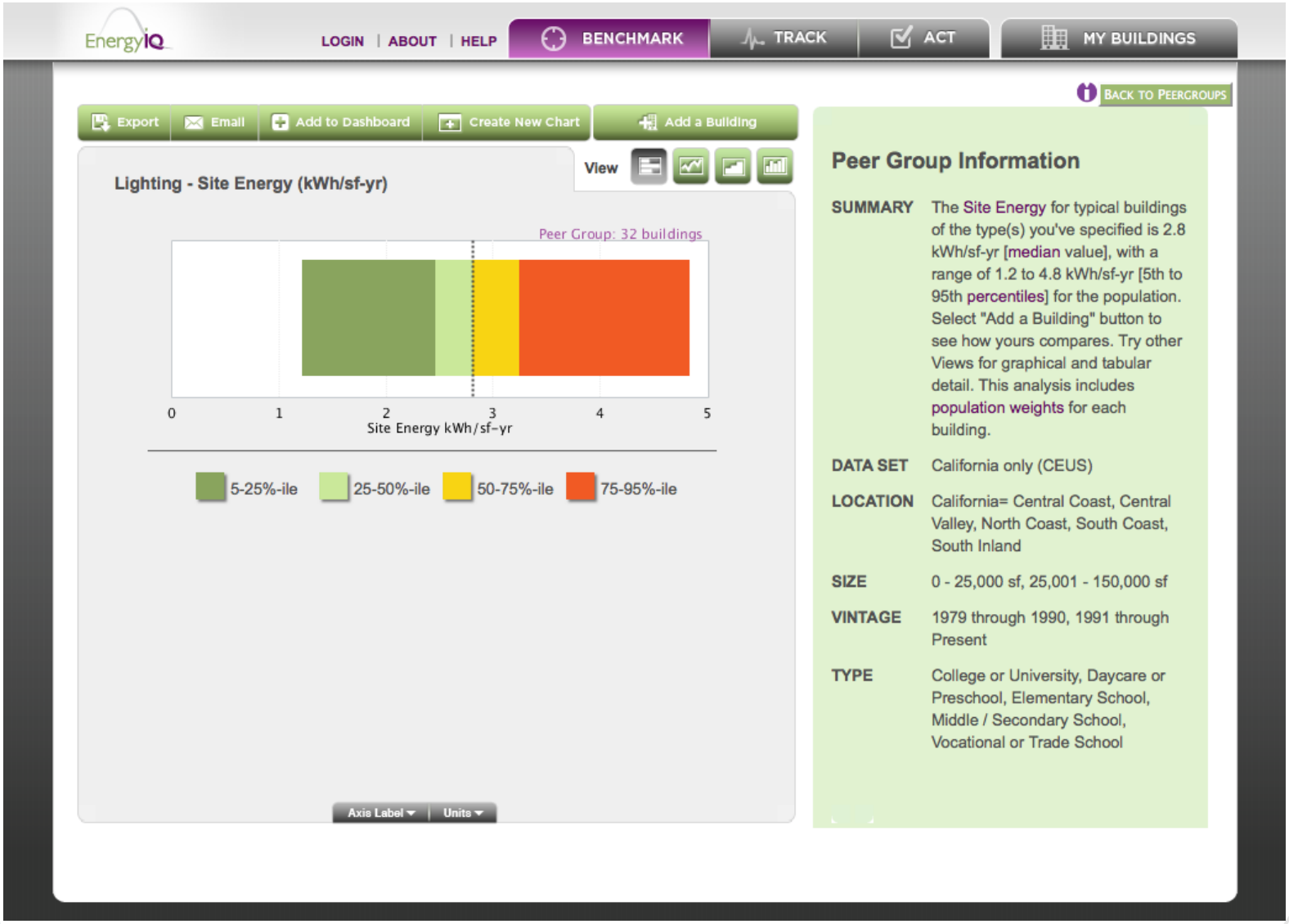
- Choose among several benchmarking views…
  - Cross-sectional
  - Longitudinal (if multi-year data is entered)
- Add your building



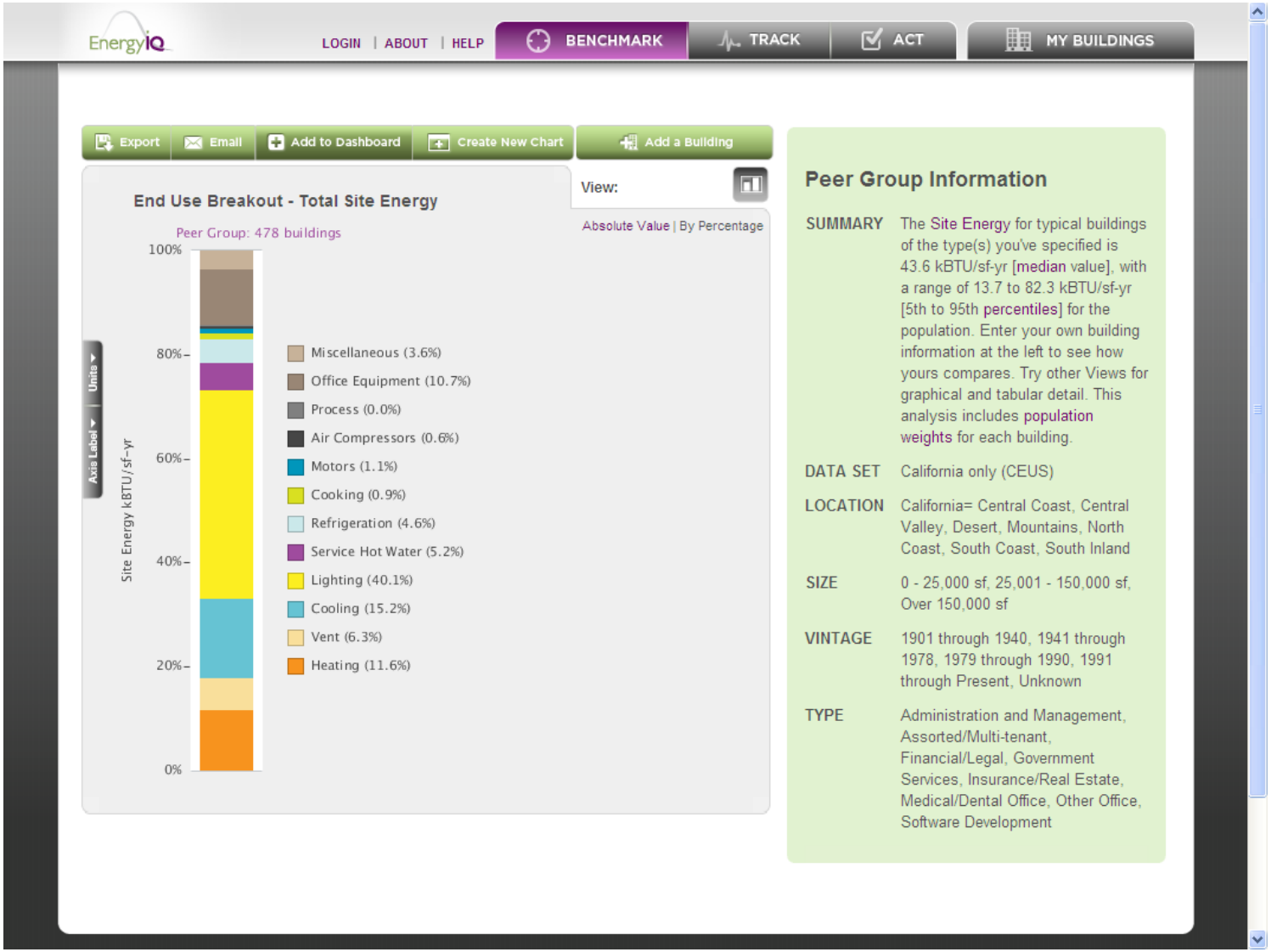
Benchmark: Ranked Bar View



Benchmark: Range Bar View

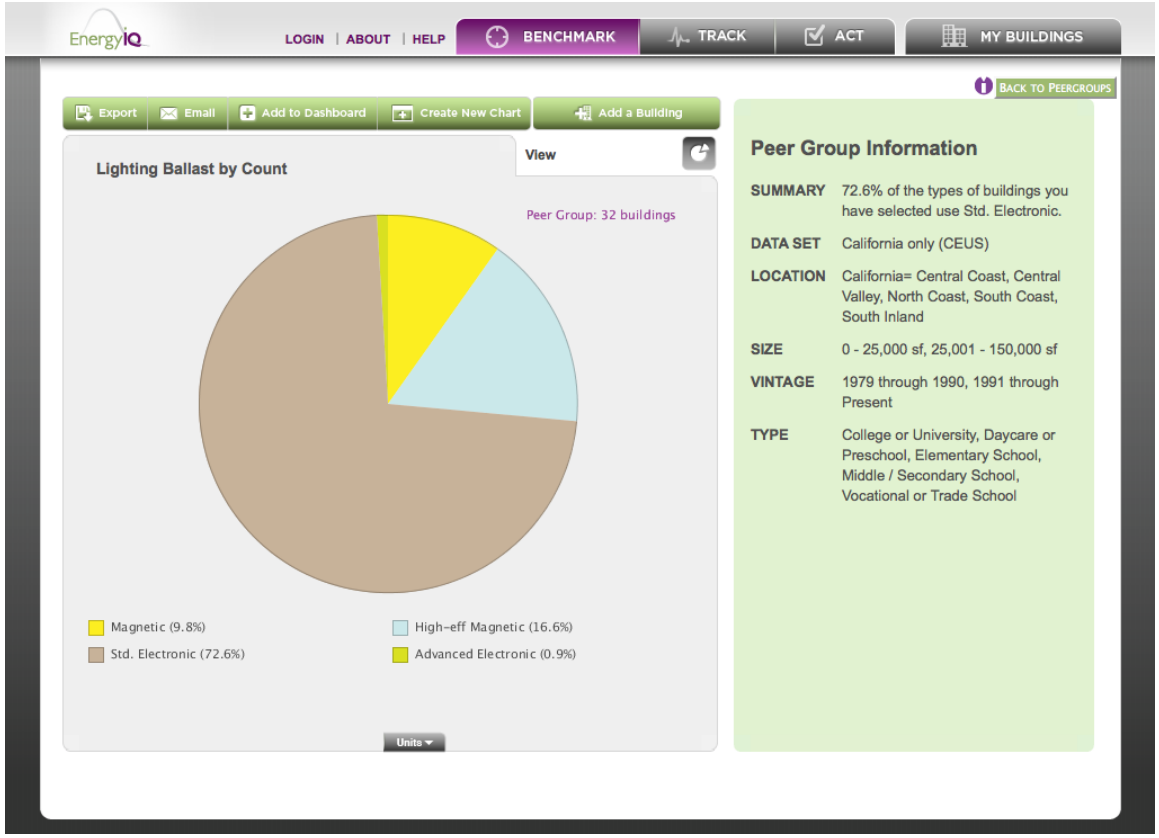


Benchmark: End-use Breakout View

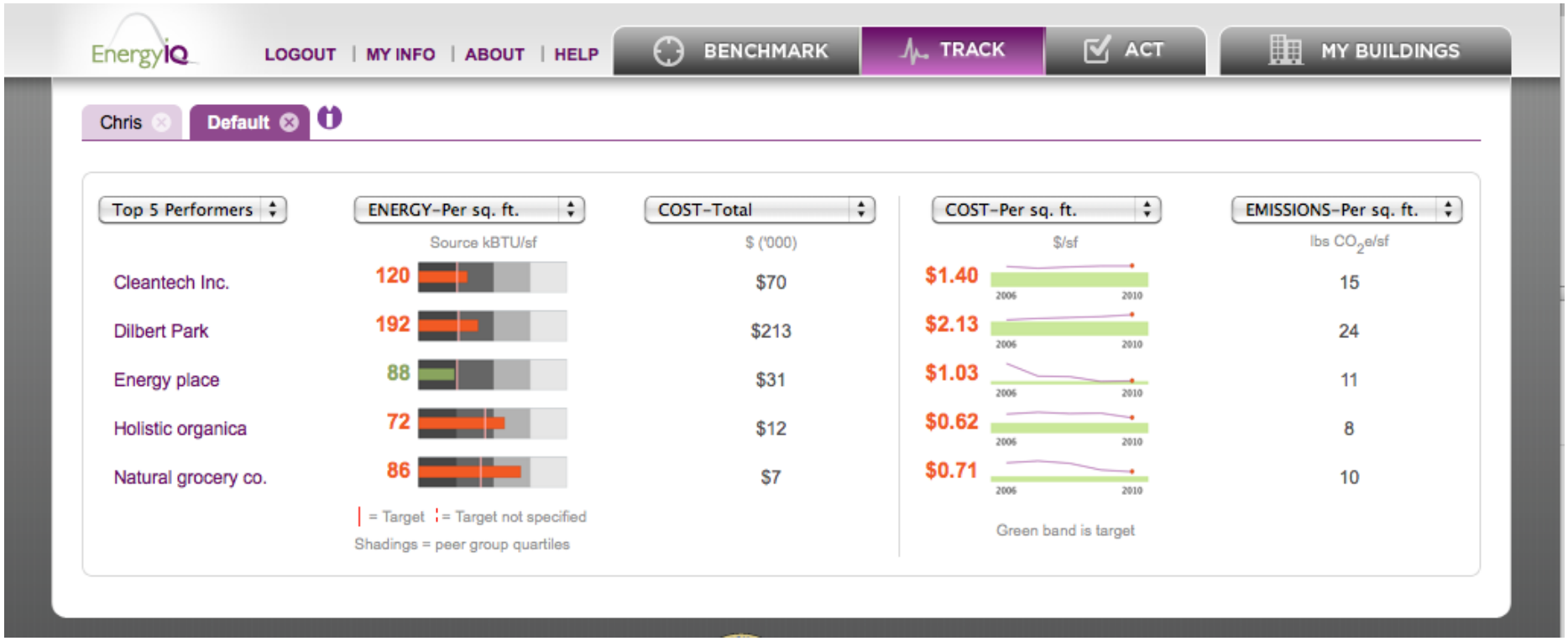


Benchmark: Building Characteristics

- When choosing "Features" instead of energy benchmarks, an analysis is shown of the frequency of types of features (lighting, hvac, envelope, etc.) in the user-selected peer-group



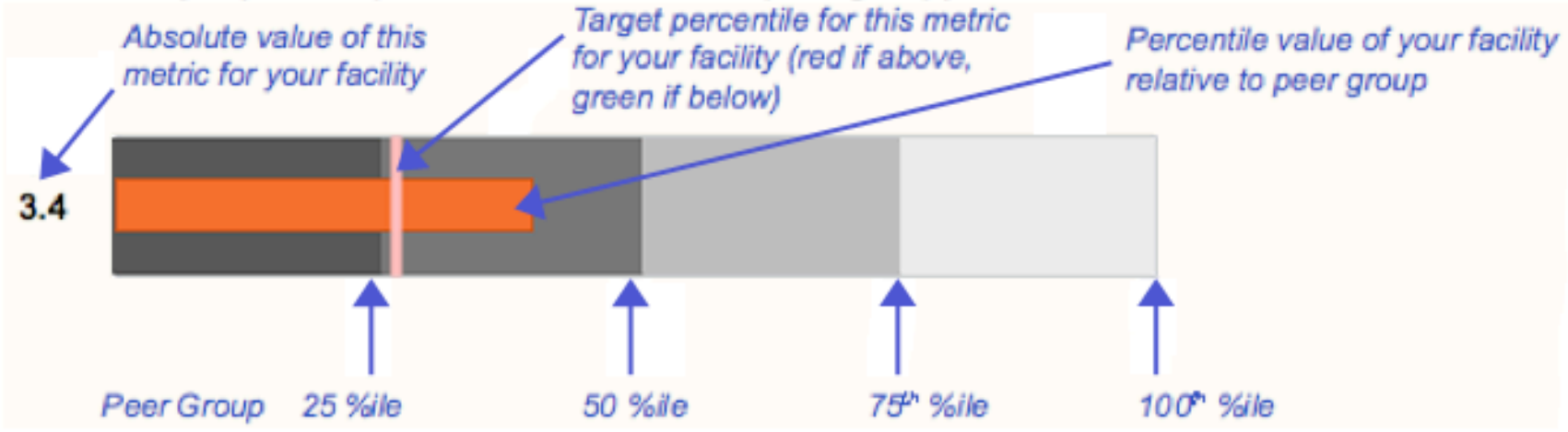
Dashboard Tab



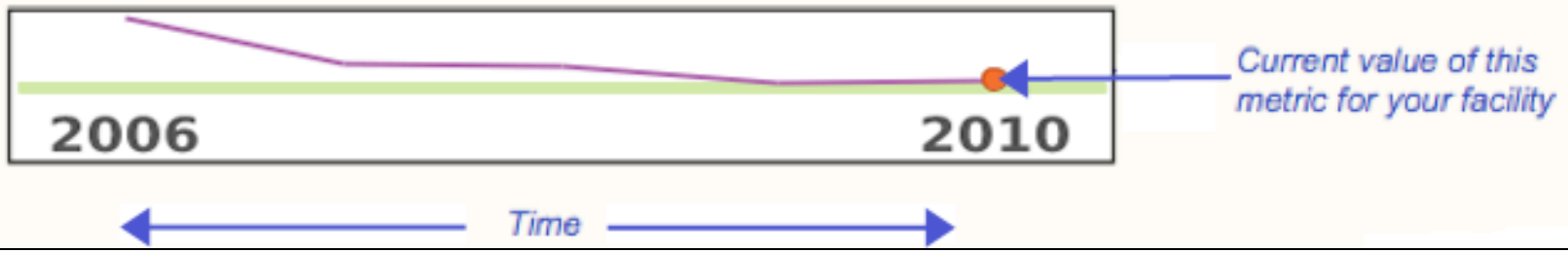
- Benchmark vs peers
- Progress towards targets (if specified)
- Progress over time

A wide range of metrics can be displayed

Bullet Graph (current performance relative to peer group)

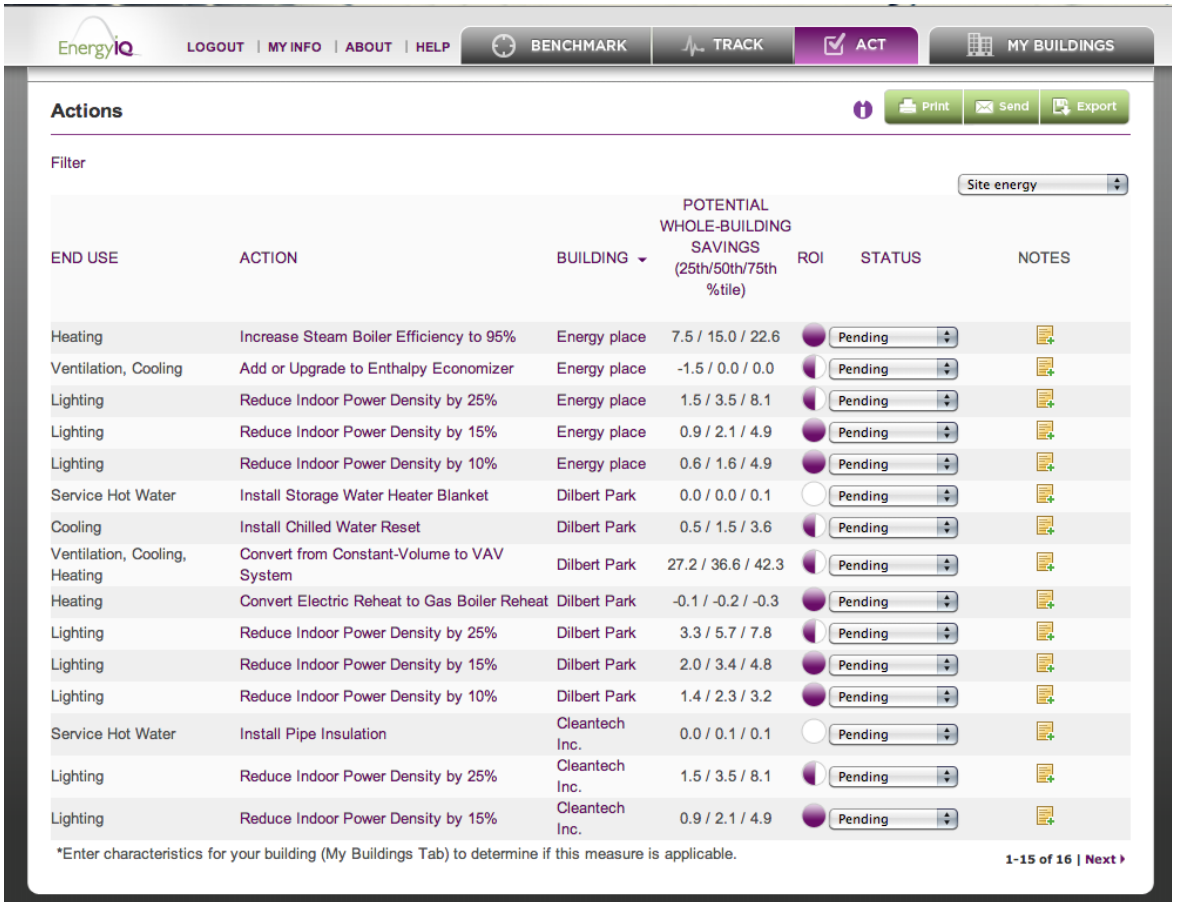


Spark Line (historical trend)



ACT Tab: Retrofit Options

- 65 potentially applicable energy upgrades for each user building => 65k bldg+measure combinations
- Ranges of savings shown, based on simulation results for all peer-group buildings (California buildings only)



END USE	ACTION	BUILDING	POTENTIAL WHOLE-BUILDING SAVINGS (25th/50th/75th %tile)	ROI	STATUS	NOTES
Heating	Increase Steam Boiler Efficiency to 95%	Energy place	7.5 / 15.0 / 22.6		Pending	
Ventilation, Cooling	Add or Upgrade to Enthalpy Economizer	Energy place	-1.5 / 0.0 / 0.0		Pending	
Lighting	Reduce Indoor Power Density by 25%	Energy place	1.5 / 3.5 / 8.1		Pending	
Lighting	Reduce Indoor Power Density by 15%	Energy place	0.9 / 2.1 / 4.9		Pending	
Lighting	Reduce Indoor Power Density by 10%	Energy place	0.6 / 1.6 / 4.9		Pending	
Service Hot Water	Install Storage Water Heater Blanket	Dilbert Park	0.0 / 0.0 / 0.1		Pending	
Cooling	Install Chilled Water Reset	Dilbert Park	0.5 / 1.5 / 3.6		Pending	
Ventilation, Cooling, Heating	Convert from Constant-Volume to VAV System	Dilbert Park	27.2 / 36.6 / 42.3		Pending	
Heating	Convert Electric Reheat to Gas Boiler Reheat	Dilbert Park	-0.1 / -0.2 / -0.3		Pending	
Lighting	Reduce Indoor Power Density by 25%	Dilbert Park	3.3 / 5.7 / 7.8		Pending	
Lighting	Reduce Indoor Power Density by 15%	Dilbert Park	2.0 / 3.4 / 4.8		Pending	
Lighting	Reduce Indoor Power Density by 10%	Dilbert Park	1.4 / 2.3 / 3.2		Pending	
Service Hot Water	Install Pipe Insulation	Cleantech Inc.	0.0 / 0.1 / 0.1		Pending	
Lighting	Reduce Indoor Power Density by 25%	Cleantech Inc.	1.5 / 3.5 / 8.1		Pending	
Lighting	Reduce Indoor Power Density by 15%	Cleantech Inc.	0.9 / 2.1 / 4.9		Pending	

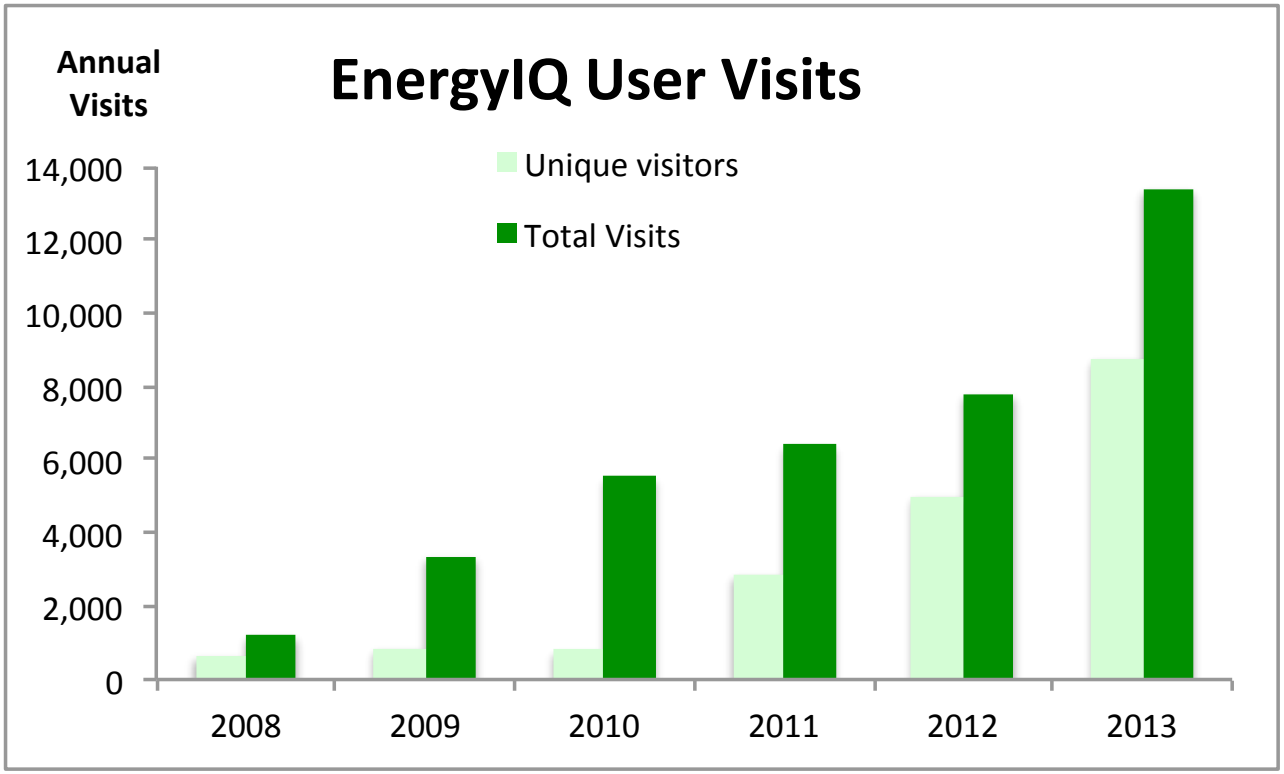
*Enter characteristics for your building (My Buildings Tab) to determine if this measure is applicable.

1-15 of 16 | Next

Deployment
&
Technology Transfer

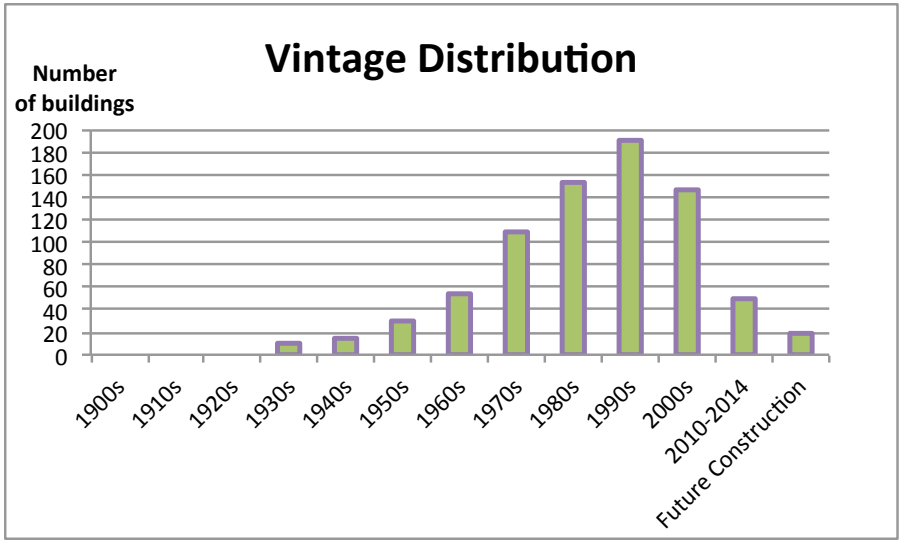
Usage: Website

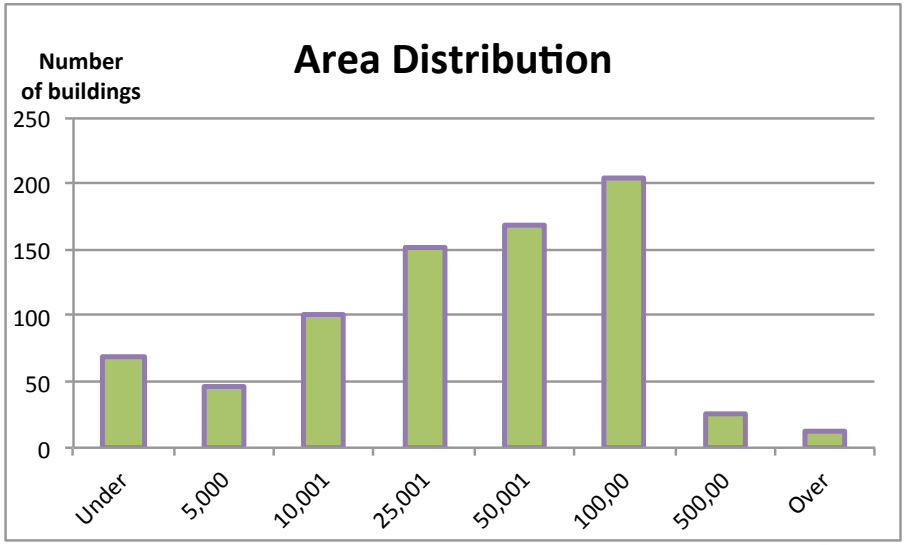
- Total visits: **43,300**
- Unique visitors: **20,000**
- ❑ Total page-views: **148,000**
- ❑ Countries: **134**



Usage: Accounts & Bldgs (as of 4/2014)

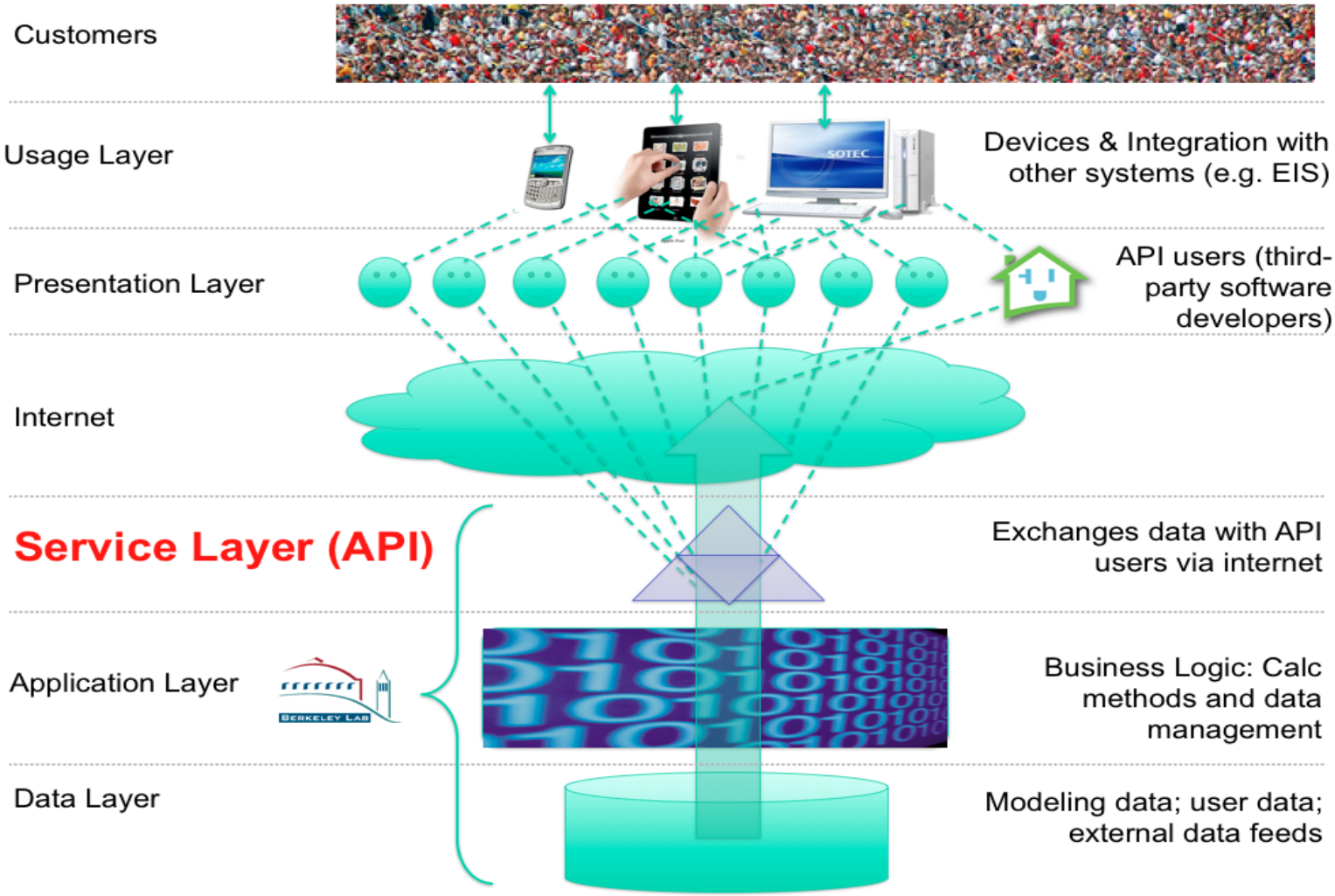
- Number of registered users: **1,139**
- Number of user-entered buildings: **781**
- Total floor area of buildings entered: **106** million ft^2





APIs…

APIs are protocols through which the a host computer and a client computer communicate and exchange data, leaving client free to decide how to gather input data from its customers and how to present them with results



APIs

Pros

- Speeds and simplifies syndication of models and databases
- Radically lowers the cost of entry for private software developers
- Developers can focus more on front-end
- Enables more rapid innovation and differentiation of tools
- Facilitates more internal consistency in methodology and data across proliferation of tools
- Ameliorates stereotypical separation between “public” and “private” tools

Cons

- Requires web-infrastructure
- Derivative tools all depend on single API provider
- Initial development is slower; user support
- Developers need special skills and to be able to understand and adapt to outside service and support paradigm
- Requires very explicit documentation for third-party developers

Usage: API Licensing
(New: available since June 2013)

- Signups: **32**
- Inquiries: **43**
- Licensees: **3**

API licensing & support site

https://developers.buildingsapi.lbl.gov/

BERKELEY LAB
LAWRENCE BERKELEY NATIONAL LABORATORY

Sign in

HOME | HOME ENERGY SAVER | SCORING TOOL | ENERGYIQ

This site provides everything website developers need to access our APIs for analyzing energy use in residential and commercial buildings.
Read about how people are using our APIs

Home Energy Saver

The Home Energy Saver tool suite and APIs--the culmination of a decade and a half of development by the U.S. Department of Energy's Lawrence Berkeley National Laboratory--provides web-based residential energy calculators for consumers and professionals. These tools provide customized estimates of residential energy use, energy bills, and greenhouse-gas emissions, based on information provided by the user. The service identifies and ranks potential energy-saving strategies for any single family detached or townhouse style home and multifamily appartment buildings.

Release History

Licensing information

Sign up

Scoring Tool

The Home Energy Scoring Tool provides an "asset rating" of a home's energy use under standardized occupancy and operational conditions. Qualified assessors can gather the information needed to assess a home in one short site visit. The tool underpins the U.S. Department of Energy's new Home Energy Score Program, designed to label homes across the country. With these APIs, approved software developers can generate home energy scores as a stand-alone service or as an add-on to a home inspection or comprehensive energy assessment.

Release History

Licensing information

Sign up

EnergyIQ

The EnergyIQ action-oriented benchmarking system enables users to compare the energy performance of a non-residential building to a user-defined peer group, and generates an opportunity assessment with general recommendations on how to save energy and money, while reducing greenhouse-gas emissions.

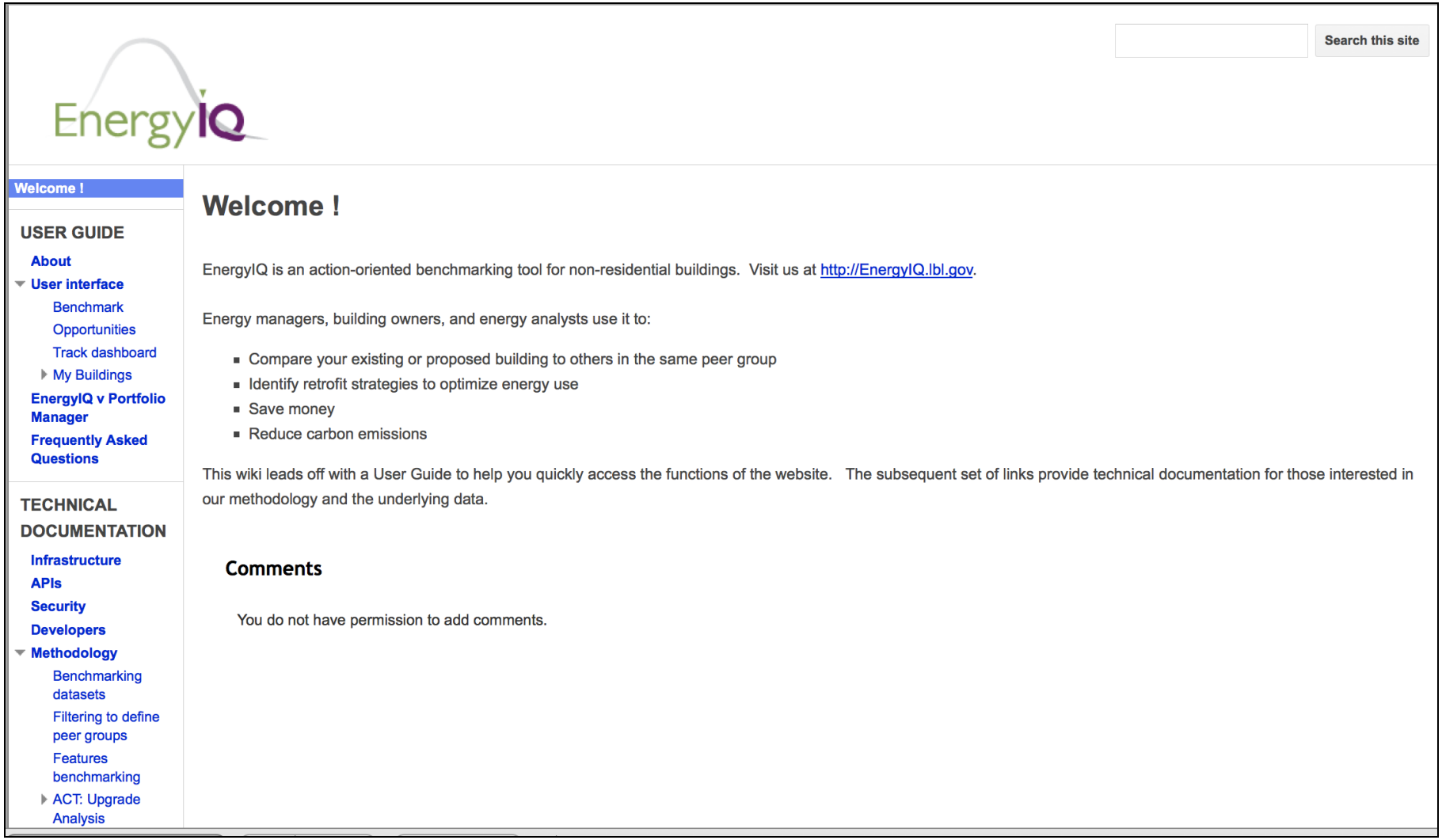
Release History

Licensing information

Sign up

Public-facing documentation

https://sites.google.com/a/lbl.gov/energyiq/



Infrastructure

- Code: The EnergyIQ APIs are written in PHP, with pervasive use of JavaScript and CSS2. EnergyIQ also supports a SOAP-based web service to allow the flow of queries and data to occur with non-browser implementations.
- Database: Oracle 10g
- Hosting: Amazon cloud

Pubs

- Mills, E. 2014. “Action-Oriented Benchmarking with EnergyIQ.” *IEEE Proceedings* (in preparation)
- Mills, E., P. Mathew, N. Bourassa, M. Brook, and M.A. Piette. 2008. "Action-Oriented Benchmarking: Concepts and Tools." *Energy Engineering*, 105(4):21-40. LBNL-358E
- Mathew, P., E. Mills, N. Bourassa, M. Brook. 2008. "Action-Oriented Benchmarking: Using the CEUS Database to Benchmark Commercial Buildings in California." *Energy Engineering*, 105(5):6-18. LBNL-502E
- Mills, E. and P. Mathew. 2012. "Web Services that Foster Innovation in Buildings Energy Analysis Tools," 2012. *Proceedings of the 2012 ACEEE Summer Study on Energy Efficiency in Buildings*, American Council for an Energy-Efficient Economy: Washington, D.C.
- Mills, E. and P. Mathew. 2014. "Monitoring-Based Commissioning: Benchmarking Analysis of 24 University Buildings in California," *Energy Engineering* 111(4):7-24